PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 8 (8): 1150-1155, 2009
ISSN 1680-5194

The Effect of Dried Sweet Orange (*Citrus sinensis*) Fruit Pulp Meal on the Growth Performance of Rabbits

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Abstract: A feeding trial was conducted with thirty six mixed breeds of rabbits to assess the feeding value of sun dried sweet orange (*Citrus sinensis*) fruit pulp meal (SOPM). The sweet orange peel meal was analyzed for its proximate nutrients and its crude fibre constituents. The nutrients in SOPM were 7.71% CP, 9.6% CF, 2.12% EE, 5.18% ash, 75.31% NFE and 3756.14kcalME/kg. The crude fibre fractions were 15.04% cellulose, 20.46% hemi-cellulose, 38.28% NDF, 18.32% ADF and 3.28% ADL. The experimental rabbits were randomly assigned to six dietary treatments: T_0, T_5, T_{10}, T_{15}, T_{20} and T_{25} in which SOPM replaced maize at 0, 5, 10, 15, 20 and 25%, respectively at the rate of six rabbits per dietary group. The rabbits were fed these diets for 84 days during which performance and nutrient digestibility were evaluated. Experimental diets had significant effects ($p<0.05$) on the body weight gain, water intake, water: feed ratio, protein efficiency ratio and final live weight. Coefficient of digestibility and nutrient digestibility, were not adversely affected by the inclusion of SOPM in the diets. This study has shown the possibility that sweet orange fruit pulp meal can be used as a replacement feedstuff for maize in the ration of grower rabbit up to a level of 20%.

Key words: Rabbit, sweet orange fruit pulp meal, performance and nutrient digestibility

INTRODUCTION

The acute shortage of animal protein in the diet of the average Nigerian is well documented (FAO, 1992). Indeed, the animal protein consumption of 3.245g per caput in Nigeria is far below the recommended 35g head day recommended by the Food and Agriculture Organization (Abubakar *et al*., 2003). One of the ways of bridging the demand-supply gap is through rearing of rabbits. Rabbit production for fast meat yield is however, affected by inadequate and high cost of feed ingredients brought about mainly by the stiff competition between man and monogastric animals for grain and oil seeds (Agunbiade *et al*., 2002). The favourable attributes of the rabbit which has projected it as a target species for curtailing protein malnutrition cannot be realized because of the high cost of conventional feedstuffs. Animal nutritionists in collaboration with livestock producers have thus intensified the search for less costly and readily available alternative feed materials. It is observed that the increasing mechanization of crop farming in developing economies has led to a rise in the tonnage of agro-allied by-products most of which lies waste. One of such wastes could emanate from the citrus, a major fruit of sub-tropical region (Rice and Rice, 1987). Sweet orange (*Citrus sinensis*) production in Nigeria is significant, with heavy direct consumption due primarily to few and small capacity processing industries to convert the fruit to juice, concentrate and canned fruit. Nigeria produces 3% of fresh citrus in the world and Africa produces 3,741,000 ton of different varieties of citrus fruits of which Nigeria contributes 3,240,000 ton (FAO, 2004). Sweet orange fruit pulp obtained after the exocarp is peeled off and the fruit juice removed is available throughout the year. It constitutes an environmental challenge since it is not being put into any productive use. The objective of this study is the nutritional evaluation of the feeding value of sun dried sweet orange (*Citrus sinensis*) fruit pulp meal and its effect on the performance of rabbits.

MATERIALS AND METHODS

The test ingredient sweet Orange fruit pulp was obtained from peeled orange retailers in Akperan Orshi College of Agriculture, Yandev, Nigeria. The test ingredient was rinsed with water to remove sand which gets attached to the pulp when discarded after the fruit juice has been sucked. The pulp was thereafter sun-dried to prevent fermentation on raised concrete platforms until it became brittle. Sun dried pulp was stored in synthetic bags tied at the open end to keep it in a dry state until it was milled using the 2-mm screen hammer mill to obtain sweet orange fruit pulp meal (SOPM) and incorporated into the experimental diets.

The experiment was carried out at the Teaching and Research Farm of the College. Yandev lies in the southern guinea savannah with an annual rainfall of 508-1041mm, average minimum and maximum temperatures of 21°C and 35°C, respectively, with the annual mean relative humidity of 60.36%. Thirty six weanling rabbits (18 males and 18 females) of mixed

breeds between 5 to 6 weeks were used as experimental animals. The rabbits had a 7-day adjustment period before the feeding trial commenced during which they were treated with ivermectin subcutaneously at a dosage of 0.1ml per rabbit against ecto-and endo-parasites. Embazin forte was orally administered through drinking water by dissolving 30g in 50 litres of water as prophylactic treatments against coccidiosis. Oxytrox L.A. was also administered subcutaneously at the dosage of 0.2ml per rabbit as prophylactic treatment against bacterial infections. At the end of the adjustment period, the experimental rabbits were weighed individually and divided into 6 groups of similar live weights consisting of 6 rabbits of 3 males and females, which were randomly assigned to six diets treatments. Each dietary treatment was replicated six times with a rabbit each serving as a replicate in a randomized complete block design. They were put in a wire cage of 40cm x 40cm x 40cm housed in a zinc roofed building with open sides for purposes of good ventilation and fenced for protection. Experimental feed in mash form and potable drinking water was served *ad libitum* for 84 days. Feed wastage and water spillage were controlled by using feeding and water troughs specially designed with inner lips and secured to the cage floor to avoid being turned upside down. Dried sweet orange fruit pulp meal was incorporated into the experimental diets T_0, T_5, T_{10}, T_{15}, T_{20} and T_{25} at the levels of 0%, 5%, 10%, 15%, 20% and 25% to replace dietary maize in the control diet. Feed intake, body weight, weight gain, feed conversion ratio (FCR), water consumption, protein efficiency ratio (PER), water:feed ratio and mortality were the response criteria used in assessing rabbit performance. Rabbits were individually weighed at the start of the trial and thereafter weekly. Protein efficiency ratio was calculated as a ratio of daily weight gain:daily protein intake. Daily water consumption per rabbit was determined accounting for evaporative loss using the procedure outlined by Shoremi *et al.* (2001). The experimental feed at the rate of 80g/rabbit was supplied daily with one-half provided in the morning (07^{00} hrs) and the other half in the evening (17^{00} hrs). The left over feed at the end of each day was subtracted from the daily feed supplied to obtain the daily feed intake. At the twelfth week, 4 rabbits, 2 males and 2 females per treatment were selected to evaluate the apparent digestibility of the dietary nutrients for 7 days. The feed allowance per rabbit was kept at 60g per day during the digestibility trial. Faecal collections for individual rabbit were done 24 hourly before fresh feed was served in the morning for a period of seven days. Fresh feaces from each replicate were weighed and re-weighed after oven-dried at 80^0C for 24 hours. Daily feed intake per replicate was recorded during this period. Collected faeces from each animal were bulked, mixed, ground and samples were analyzed for their proximate constituents. The proximate analysis of SOPM and the experimental diets was carried out according to AOAC (1995). The characterization of the crude fibre of SOPM was done as described by Price and Butler (1980). Data obtained was subjected to two-way analysis of variance (ANOVA), using the Minitab Satistical Software (1991). Where significant differences were observed, means were compared by Duncan's Multiple Range Test as outlined by Akindele (1996).

RESULTS AND DISCUSSION

The proximate composition of dried SOPM shows that it can be nutritionally evaluated as a possible substitute for maize in rabbit diet. Its crude protein (CP) and energy contents of 7.71% and 3756.14kcal ME/kg, respectively (Table 1) suggest that this citrus waste can be classified as energy feed. Its high crude fibre (CF) content (9.68%) may be an advantage in rabbit nutrition since this livestock species requires a higher dietary crude fibre (minimum requirement of 9%) recommended by Spreadbury and Davidson (1978) than poultry and swine. The crude fibre fractions show that SOPM contains 3.28% acid detergent lignin (ADL). This is an indication that the fibre component of SOPM contains more of digestible carbohydrates than indigestible. The gross and proximate compositions of the experimental diets are shown in Table 2. The crude protein level in the diets was about 18% and it's within the range of 16-17 % (Anugwa *et al.*, 1982; Aduku and Olukosi, 1990), 18% (Omole, 1982) and 19% (Omar *et al.*, 1997) reported as the best for rabbit performance in the tropical environment. The CF levels in the experimental diets are adequate for weanling-growing rabbits. Igwebuike *et al.* (1998) recommended 11.0 to 15% as being adequate for normal growth of rabbit and to reduce incidences of gastroenteritis. The dietary fat, ash, dry matter and digestible energy levels in the experimental diets are within what was reported by Arrington *et al.* (1974), DeBlas *et al.* (1981), Omole *et al.* (2003) and Lebas (1975), respectively. The nitrogen free extract (NFE) which represents the readily available carbohydrates are also within the range reported for rabbits (DeBlas *et al.*, 1981).

The performance response of rabbits to dietary maize replacement with SOPM is presented in Table 3. The feed intake in this experiment varied from 57.9 to 63.3 g/rabbit/day and was not significantly different ($p>0.05$). The effect of the experimental diets on the average weight gain of 10.76 to 13.05g was significant ($p<0.05$). It is similar to weight gains of 10.99 to 15.18g reported by Nworgu and Ogbosuka (2003) for weaned rabbits fed ripe plantain peels meal as alternative energy source and within the normal range for most rabbits reared in tropical environment (Cheeke, 1987). While rabbits in T_{15} had the highest daily body weight gain, the least body weight gains of 10.76g in the T_{25} group was statistically

Table 1: Nutrient composition of Sweet orange (Citrus sinensis) fruit pulp meal and its crude fibre fractions

	Feedstuffs	
Nutrients (%)	S0PM	Maize[1]
Dry matter	96.55	86.00
Crude protein	7.71	9.00
Ash	5.18	1.30
Ether extract	2.12	4.00
Crude fiber	9.68	2.70
NFE	75.31	83.00
[2]ME (Kcal/kg)	3756.14	3432.00
Crude fibre constituents		Proportion (%)
Cellulose		15.04
Hemi-cellulose		20.46
Neutral detergent fibre (NDF)		38.28
Acid detergent fibre (ADF)		18.32
Acid detergent lignin (ADL)		3.28

[1]Aduku (1992). [2]Metabolizable energy as determined using Carpenter and Clegg (1956)

similar to 12.39g for the control (T_0). This shows that SOPM up to 25% maize replacement in rabbit's diet can be used as an alternative dietary energy feed resource. As the quantity of maize replaced by SOPM increased from 0 to 25%, the daily water consumption increased significantly ($p<0.05$) from 192.50 to 280.83ml most probably as a response to the nature of the diets. The increase in water consumption by rabbits as the level of SOPM increased may be related to the increasing bulkiness of the diet as reported by Agunbiade *et al.* (2002). The range of the minimum and maximum average daily water consumption in this study was higher than the water intake regime of 274.23 to 293.10ml when sweet orange rind was used to replace maize in growing rabbit diets Oluremi *et al.* (2005). The water: Feed ratio differed significantly ($p<0.05$) among the treatments. The result revealed that rabbits on the SOPM diet required a significantly higher water intake per g of feed consumed than the rabbits on the control diet. Water intake was between 3 to 4 times more than their corresponding feed intake. A level of up to 5 times has been reported (Gillespie, 1992). Drinking water requirement of rabbits is variable, being higher in the young rabbits than in the older ones in order to meet the demand for active metabolism process associated with positive growth. The rabbits used in this experiment were freshly weaned rabbits (5-6 weeks) which were in the growing phase, hence justifying their high water intake. Water intake in farm animals had earlier been reported by Shoremi *et al.* (1998) to be closely related to the amount and type of food eaten. The feed conversion ratios of 4.69 to 6.21 were obtained in this study. While the FCR may suggest a nutritive superiority of maize over SOPM, the effect of SOPM inclusion in rabbit diet did not affect FCR significantly ($p>0.05$). The experimental diets had a significant effect ($p<0.05$) on PER It varied from 0.74 to 1.04. The efficiency of rabbits to convert dietary protein into flesh (edible meat) did not differ statistically up to 20% level of maize replacement with SOPM. No mortality was recorded during the feeding trial. This suggests that, up to 25% maize replacement by SOPM did have any adverse effect on the rabbits. They did they show any signs of distress.

Table 2: The gross composition of the experimental diets (%)

	Experimental Diets					
Feeding stuffs	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}
SOPM	0.00	5.00	10.00	15.00	20.00	25.00
Yellow Maize	48.38	43.11	37.84	32.58	27.30	22.04
FFSB[1]	25.12	25.39	25.66	25.92	26.20	26.46
Rice Offal	17.00	17.00	17.00	17.00	17.00	17.00
BDG[2]	6.00	6.00	6.00	6.00	6.00	6.00
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Analyzed Chemical Composition (%DM):						
Dry matter	89.64	89.22	89.30	89.38	90.14	90.70
Crude protein	17.85	17.93	17.92	17.90	17.75	17.64
Crude fibre	10.90	11.38	11.79	12.20	12.54	12.90
Crude fat	4.92	2.48	2.68	2.71	4.13	4.20
Ash	7.63	4.97	5.33	5.50	7.12	7.59
NFE	58.70	63.24	62.28	61.69	58.46	57.67
DE (kcal/kg)[3]	2734.00	2693.00	2714.00	2719.00	2613.00	2726.00

[1]Full fat soybeans, [2]Brewers dried grain. *Vitamin/ Mineral Premix: Each 1kg contains Vit. A 150000 I.U, Vit. D 3000 I.U, Vit. E 300 I.U, Vit. K 25mg, Pantothenic acid 100mg, Pyridoxine 49.99mg, Niacin 400mg, Vit. B_{12} 0.20 mg, Folic acid 10mg, Biotin 0.80mg, Choline chloride 5g, Anti-oxidant 1.25mg, Iron 0.24g, Copper 0.06mg, Iodine 0.014g, Selenium 2.40mg, Cobalt 2.40mg

$$[3]\text{Digestible energy} = \frac{\text{Coefficient of digestibility of energy x Gross energy consumed}}{100}$$

Table 3: The effect of diets containing Sweet orange (Citrus sinensis) fruit pulp meal on the growth performance of Rabbits

	Experimental diets						
Performance indices	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}	SEM
Av. initial weight (g)	667.17	639.17	652.67	654.00	656.92	629.50	23.27^{NS}
Av. final weight (g)	1708.33^{ab}	1613.33^{bc}	1725.00^{ab}	1750.00^{ab}	1700.00^{ab}	1533.33^{c}	58.38*
Av. weight gain (g/day)	12.39^{ab}	11.60^{ab}	12.82^{ab}	13.05^{a}	12.42^{ab}	10.76^{b}	0.67*
Av. feed intake (g/day)	57.90	59.30	60.30	63.30	62.70	62.60	1.77^{NS}
Av. water intake (ml/day)	192.50^{b}	217.50^{b}	250.83^{a}	257.50^{a}	263.33^{a}	280.83^{a}	11.04*
Water:feed ratio	3.32^{f}	3.67^{e}	4.16^{c}	4.06^{d}	4.20^{b}	4.49^{a}	0.001*
FCR	4.69	5.20	5.10	4.89	4.74	6.21	0.61^{NS}
PER	0.93^{a}	1.01^{a}	1.04^{a}	1.00^{a}	0.86^{ab}	0.74^{b}	0.06*
Mortality (%)	0	0	0	0	0	0	-

^{a,b,c,d,e,f}Means within rows with different superscripts are significantly different ($p<0.05$). ^{NS}Not significant ($p>0.05$),
SEM = Standard error of mean

Table 4: Mean apparent nutrient digestibility (coefficient of digestibility) of Rabbits fed diets containing Sweet orange (Citrus sinensis) fruit pulp meal(%)

Nutrients	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}	SEM
Dry matter	65.90	65.90	61.80	65.30	64.00	65.20	0.85^{NS}
Crude protein	86.70	83.30	84.60	81.20	84.70	84.70	1.88^{NS}
Crude fibre	93.20	93.30	93.40	92.20	93.20	92.70	0.87^{NS}
Crude fat	91.10	91.60	91.40	89.40	88.90	91.10	0.98^{NS}
Ash	92.20	91.60	89.90	89.90	92.10	90.60	1.69^{NS}
NFE	53.10	54.00	54.00	54.30	55.40	56.80	1.02^{NS}

^{NS}= Not significant ($p>0.05$), SEM = Standard error of mean

Table 5: The percentage of digestible nutrients and total digestible nutrient (TDN) of Rabbits fed diets containing sweet orange (Citrus sinensis) fruit pulp meal

Nutrients	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}	SEM
Digestible crude protein	22.26^{a}	18.73^{b}	19.35^{b}	18.83^{b}	21.71^{a}	22.14^{a}	0.36*
Digestible crude fibre	3.79	3.86	3.94	3.89	3.82	3.83	0.03^{NS}
Digestible crude fat	3.67	3.77	3.67	3.54	3.67	3.85	0.05^{NS}
Digestible NFE	27.73	30.48	30.29	29.97	28.33	29.70	10.56^{NS}
TDN	62.02	61.54	61.83	60.83	62.12	64.27	0.76^{NS}

^{a,b}means within rows with different superscripts are significantly different ($p<0.05$). ^{NS}Not Significant ($p>0.05$),
SEM = Standard error of mean

The apparent digestibility coefficient of nutrients is represented in Table 4. The experimental diets did not adversely affect the apparent digestibility coefficient of any the nutrients. A major contribution of SOPM into the rabbit diets was crude fibre. Above the acceptable limit and also depending on the nature of the crude fibre constituent, digestibility of nutrient are affected. It is known that, fiber in the diet of monogastrics impairs the utilization of other nutrients especially crude protein (Delmore and Wojeik, 1982). Adegbola and Okonkwo (2002) showed that, there is negative correlation coefficients between crude fibre and nutrient digestibility, an indication that high crude figure in the diet depresses nutrient digestibility. The CF levels of 10.90-12.90% in this study were within the acceptable range, thus the digestibility of the nutrients with the exception of NFE were high. The high and comparable coefficient of digestibility of crude fibre in all the dietary treatments (92.20 to 93. 40%) shows that, the SOPM dietary fibre contains more of digestible carbohydrate than indigestible. The acid detergent lignin present in SOPM fibre is 3.28%. The digestibility of crude fibre has been shown to be modified by the degree of lignification of the dietary fibre rather than the fibre level and differences in feed consumption (Diaz-Arca *et al.,* 1999). The NFE which represents the readily available carbohydrates recorded a moderately low coefficient of digestibility (53.10 to 56.80%). This can not be linked to the SOPM since the apparent coefficient of digestibility of the control group was comparable to the SOPM based diets. The moderately high coefficient of digestibility of dry matter of the rabbits in this study indicates that the dietary crude fibre levels did not induce excessive production of mucin to increase the viscosity of the digesta within the gastrointestinal tract.

The digestible nutrients and total digestible nutrient (TDN) are presented in Table 5. The experimental diets affected the digestible crude protein (DCP) by rabbits significantly ($p<0.05$). The digestible crude protein at 0, 20 and 25% maize replacement levels by SOPM were statistically higher than at 5, 10 and 15% levels. This however cannot be linked to the incorporation of SOPM in the diets, since no particular sequence was followed. The digestible crude fibre (DCF), digestible ether extract

(DEE), digestible ash, digestible nitrogen-free extract (DNFE) and total digestible nutrients (TDN) were not adversely affected by the incorporation of SOPM in the dietary treatments, since they did not differ significantly ($p>0.05$) among the dietary treatments. The total digestible nutrients (TDN), a measure of the relative energy value of a feed to an animal was moderately high and within a close range (60.83 to 64.27%). The dry matter digestibility of the experimental diets (61.80 to 65.90%) were similar to TDN values. It is thus apparent that the crude fibre content of the diets did not interfere with nutrient availability at the tissue level and adequate nutrients were available for growth and maintenance. Increasing proportion of SOPM in the diets did not adversely affect their TDN.

Conclusion: The result of this study have shown that up to 25% dietary maize in rabbit diet can be replaced with sun dried SOPM without negative effects on the performance of rabbits. As a high energy and protein source like maize, its inclusion in rabbit feed formulation would help to reduce the cost of feed. It is therefore, suggested that its practical abundance should be exploited as a significant leap to reduce the high demand on maize, its accompanying high cost and its direct effect on the cost of finished table meat product.

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